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A METHOD FOR BREEDING PIERIS NAPI AND PIERIS BRYONIAE

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SINCE THE YEAR 1942 the author has bred *Pieris napi* L. and *Pieris bryoniae* Ochs. over a number of years. This breeding was carried out mainly in order to obtain information on the genetical, ecological, and taxonomical relationships between the two forms (cf. Petersen 1963, in press, and literature cited there). This paper will deal with the breeding methods used and some results obtained in this connection.

MATING

For copulation males and females were put together in cylindrical cages made of cotton net with a bottom of treetex. The cages were 2-4 dm high and had a diameter of 2-3 dm. In such a cage 2-4 females and a slightly larger number of males were placed. The cages were hung up in a window facing towards the south. Quite soon it was obvious that mating propensity was higher for *napi* in sunshine and for *bryoniae* in cloudy weather (cf. table 1). Mating propensity means in this case the frequency of mating of one sex compared with the same sex of the other species. The difference is statistically significant ($\chi^2=16.37$ with Yates' correction; $P<0.001$). Müller and Kautz (1938 p. 15) state that sunshine is essential for the copulation of *bryoniae.* In nature *bryoniae,* like *napi,* copulates in sunshine. The experiments indicate only different ecological amplitudes for the copulation of the two species.

Matings under laboratory conditions were fairly easily obtained, not only by the author in Sweden, but also by Bowden and Easton in England (Bowden 1953, 1956, 1957, Bowden and Easton 1955). Entomologists in Central Europe, on the other hand, have had a number of difficulties in obtaining such matings. Some few experiments on hybridization have been reported by Fischer (1924, 1925) and Kautz (Müller and Kautz 1938 p. 159-161). The lack of success in many of the Central European experiments may be due to too high temperature during sunshine in Central Europe. The temperature in the windows used by the author, when the experiments were made in April and May, was usually about 24°-27°C. In the sunshine of Central European laboratories the temperature probably is higher, especially as the experiments usually are carried out during the summer months.

TABLE 1. Number of matings (f) of animals tested on mating propensity (m) under different conditions. Simplified from Petersen and Tenow, 1954, p. 182.

	sunshine		cloudy weather	
	f	m	f	m
napi	31	0.84	1	0.14
bryoniae	6	0.16	6	0.86
napi	22	0.76	2	0.29
bryoniae	7	0.24	5	0.71

TABLE 2. Survivals from growing P. bryoniae from Abisko, northern Sweden.

temperature	number of		
	eggs	larvae	pupae
4°	10	0	0
8°	10	3	0
13°	10	9	6
16°	10	10	9
20°	20	20	11
28°	10	7	0
32°	22	14	0
34°	5	0	0

EGG-LAYING

After copulation, the female was transferred into a cage with some flowers to feed on and leaves of a species of the family *Cruciferae* for egg-laying. *P. bryoniae* in nature lays the eggs almost exclusively on a single plant species, *Biscutella laevigata.* In one cage experiment a female preferred some other plants to *Biscutella,* about 80 eggs being laid on them and none on *Biscutella* (Petersen l.c.). Thus, every plant appropriate for the egg-laying of *napi* seems to be appropriate for *bryoniae.* However, most plants of families other than *Cruciferae* as well as some few species of this family are not eaten at all by the larvae.

TABLE 3. Results from breeding P. napi - bryoniae from four localities in Sweden. l. = number of newly hatched larvae, p. = number of pupae.

temp.	Scania			Uppsala			Murjek			Abisko		
	l.	p.	%	l.	p.	%	l.	p.	%	l.	p.	%
11°-12°	30	11	37				10	2	20	15	0	0
15°-16°	22	7	32	25	19	76				11	1	9
16°-17°	85	46	54	5	5	100	4	3	75	24	12	50
19°-20°	153	119	78	45	26	58	17	8	47	33	19	58
22°-23°	43	29	67				5	2	40	36	11	31
25°-26°	92	47	51	5	4	80						

STERILITY

In many broods of the species as well as of their hybrids, the eggs do not develop at all or only partly. Sterility appears with almost the same frequency in both types of crosses, 6 broods of 30 in the pure species, 6 of 28 in the hybrid crosses. Sterility is slightly more frequent among Bowden's F_1 hybrids and backcrosses, but the difference is not significant. The F_2 and F_3 crosses, on the other hand, have a significantly higher frequency of sterility, when compared with the F_1 crosses and back-crosses of Bowden ($x^2 = 5.94$ with Yates' correction, $0.02 > P > 0.01$).

TEMPERATURE

The influence of temperature on the breeding results was investigated in two series of experiments. In the first series, material from Abisko in northern Sweden was used. *P. bryoniae* flies here from 400 m up to 800 m in the subalpine and the lower parts of the alpine regions. The breeding results are shown in table 2. The optimal constant temperature for eggs and larvae was found to lie between 13° and 20° C. As the hibernating pupae require a rather low temperature the experiments were stopped at pupation.

In the second series, material from four Swedish localities was used (cf. table 3). The Abisko material developed fairly successfully from newly hatched larvae to pupation at 16° - 23° C. The material from Abisko was perhaps a little weaker than that in the experiment already described, as the eggs had to be sent by mail. The material from southern Sweden (Scania) developed at temperatures varying from 11° to 26° C. The adaptation to different climates is obviously not strong enough to show up in experiments on such a small scale, especially near the upper and lower limits of temperature.

DISEASES

A successful breeding is dependent, not only on appropriate food and temperature, but also on the health of the animals. Virus diseases often cause the blackening and death of the larvae. The cultures started first usually develop well, only some of the latest-developing larvae being affected. In later cultures the disease spreads like a pest, killing the larvae in great numbers. The results of table 3 may therefore better be expressed as different resistance to the disease at different temperatures, or perhaps as varying virulence of the virus, than as a direct effect of the temperature.

Most years, the larvae were kept in glass jars on cut leaves. As the disease seemed to spread more rapidly on wet leaves, it was decided to start breeding on living plants growing in flower pots. The results were promising in that the frequency of virus disease became very low. The fecundity of the animals, on the other hand, was not very high during this last year of more extensive breeding. It has been stated by several breeders of *Pieris napi* that it is impossible to breed many generations without crossing with fresh material taken in nature. The animals used belonged to the fourth generation in captivity and were unfortunately the only ones available at the time.

The best way of breeding *Pieris napi* has still to be investigated. Breeding at 20° C on a living plant of the family *Cruciferae*, which is easy to keep in flower pots, will probably give better results than any so far known. *Biscutella laevigata*, which grows as a weed in the gardens of Italy, will perhaps be the best food-plant for *P. bryoniae*.

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